DOCUMENT RESUME

ED 305 230 SE 050 408

AUTHOR Ditchfield, Christine, Comp.
TITLE Better Science: For Young People with Special Educational Needs Curriculum Guide 8.
INSTITUTION School Curriculum Development Committee, London (England).; Secondary Science Curriculum Review, London (England).
SPONS AGENCY Association for Science Education, Cambridge (England).
REPORT NO ISBN-0-435-54821-2
PUB DATE 87
NOTE 34p.; For the curriculum review see SE 050 400; for other curriculum guides in this series see SE 050 401-412.
AVAILABLE FROM Heinemann Educational Books, Inc., Halley Court, Jordan Hill, Oxford OX2 8EJ, United Kingdom ($44.40 English pounds per set).
PUB TYPE Reports - Descriptive (141) -- Viewpoints (120) -- Guides - Non-Classroom Use (055)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Curriculum Development; Educational Improvement; Elementary Secondary Education; Foreign Countries; *Individual Needs; Instructional Development; Instructional Improvement; *Science Curriculum; Science Departments; Science Education; Science Instruction; Science Teachers; *Secondary School Science; *Special Education; Special Programs; *Student Needs
IDENTIFIERS *United Kingdom

ABSTRACT

This publication is one in a series of 12 giving the recommendations that were made for a broad and balanced education program in science for young people. It examines science teachers' concerns about the science education of children with learning difficulties, sets this within the context of special education, concentrates on ways to provide access to science education, and is aimed at teachers in mainstream schools, special schools, and units. Section one considers these main ideas along with the lessons learned from surveys, an evaluation of curriculum materials, and the Assessment of Performance Unit about student capabilities. Section two reviews the identification of the needs of individuals. Section three describes the moves that have been made in two schools to provide access to science education for young people with special needs while section four outlines some principles for teachers to consider when developing their own strategies to give access to science education for young people with learning difficulties. Also presented are an introduction, a list of references, and a list of additional sources of information. (RT)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED305230

SECONDARY SCIENCE CURRICULUM REVIEW

BETTER SCIENCE:

For young people with special educational needs

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Eluned Harries

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Curriculum Guides

2

SECONDARY SCIENCE CURRICULUM REVIEW

SSCR

BETTER SCIENCE:

For young people with special educational needs

Curriculum Guide 8

Compiled by Christine Ditchfield

Heinemann Educational Books/Association for Science Education
for the School Curriculum Development Committee

The Secondary Science Curriculum Review has run from 1981–1986 (Phases 1 and 2), with a dissemination phase (Phase 3) from 1986–89.

The Review operates under the aegis of the School Curriculum Development Committee and is supported by the Association for Science Education. In addition, it receives or has received support from the Department of Education and Science, local education authorities, the Schools Council (Phase 1), the Northern Ireland Council for Educational Development (Phase 2), the Health Education Council (Phase 2), industry (particularly British Petroleum), the Department of Trade and Industry and the Independent Broadcasting Authority.

Acknowledgements

The ideas presented in this Guide are not only the result of the work of SSCR groups. Their production has also relied on considerable discussion in, and on the collective wisdom of, the SSCR Central Team:

Beverley Bell (CLIS Project Coordinator 1984–85), Di Bentley (Research and Development Officer, Health and Science Education 1983–86), Paula Bower (Information Officer 1984–86), Christine Ditchfield (Southern Regional Project Officer), Dave Ebbutt (Evaluation Officer 1983–86), Kate Ellington (North West Regional Project Leader 1983–86), John Heaney (Midlands Regional Project Officer), Joseph Hornsby (North Regional Project Officer), Ruth Jarman (Northern Ireland Regional Project Leader 1983–84), Jeff Kirkham (Director from 1986; Director Designate 1985–86), Anna Larter (Project Administrator), Mick Michell (Director 1985–86; Deputy Director 1982–85), Val Oldham (CLIS Project Coordinator 1985–86), Denis Stewart (Regional Project Officer Wales & West Midlands from 1986; Northern Ireland Regional Project Leader 1984–86), Jeff Thompson (Chairman, SSCR Steering Committee), Mike Watts (Anglia Regional Project Leader 1983–86), Dick West (Director 1981–85), Cathy Wilson (ASE/SSCR Liaison Officer).

The compiler wishes to thank all those who helped by attending advisory group meetings, responding to early drafts, and checking texts, particularly: Paul Denley, Carroll Nicholl, Steve Pople, Ian Telfer, Gwyn Williams, Gill Coombes, Phil Emmel, Dave Berrington, Mike Hinson, Rod Taylor, Libby Faulkner Hall, Brian Richards, Ruth Nicholls, Neill Travers, Sue Duncan, John Nellist, Keith Weller, Brian McGarvey, Joseph Hornsby, Trevor Kirkland, Caroline Skilling, Ann Craft, Dave Wilkinson, and Members of the Hampshire SSCR Special Needs group.

The publishers wish to thank the following for permission to use extracts from other publications:

Dave Berrington, the headteachers of Little Heath, Brookfield and The Avenue Schools, and the Royal County of Berkshire Department of Education for the case study in Section 3; Cheshire County Council Education Department for the extracts from *CHASSIS*; Dr M.J. Kershaw, Worcester Sixth Form College, for the Hereford SSCR working group's profile checklist; Hampshire Education Authority for extracts from the Hampshire SSCR working group's report *Science for children with mild and moderate learning difficulties*; Colin R. Turner, on behalf of J. Slade, Science Adviser for the County of Cleveland Education Committee, for the Cleveland SSCR working group's social skills checklist; and the Resources for Learning Development Unit, Avon Education Authority, for the skills checklist and table of areas of experience in Section 1.

Heinemann Educational Books Ltd
22 Bedford Square, London WC1B 3HH

LONDON EDINBURGH MELBOURNE AUCKLAND
SINGAPORE KUALA LUMPUR NEW DELHI
IBADAN NAIROBI JOHANNESBURG
PORTSMOUTH (NH) KINGSTON

The Association for Science Education,
College Lane, Hatfield, Herts.

ISBN 0 435 54821 2

© SCDC Publications 1987
First published 1987

Typeset by Castlefield Press, Wellingborough, Northamptonshire
Printed and bound in Great Britain by
Scotprint Ltd, Musselburgh

Contents

Introduction 1
Who has special needs? 1
Purposes of science education 2
Overview of the publication 4

SECTION ONE **Meeting needs: reviewing current practice** 5
Current science provision 5
Evaluating existing curriculum materials 6
What can students do? Learning from APU findings 7
Considering your own provision 8

SECTION TWO **Identify the needs of individuals** 9
Introduction 9
Previous progress in primary and middle schools 10
Information from other sources 10
Planning the curriculum to facilitate information gathering 11
Collecting information from individual students 12

SECTION THREE **A case study** 15
Special school/mainstream school collaboration 15

SECTION FOUR **By responding to their needs we make science accessible** 19
Introduction 19
Content 19
Contexts 21
Teaching and learning approaches 21
Assessment 23
Organisation 24

Further reading 26

References 27

Foreword

This is the eighth in a collection of twelve Curriculum Guides from the Secondary Science Curriculum Review, published jointly by Heinemann Educational Books and the Association for Science Education.

A *Directory of Resources* and a book, *Better Science: Making it happen*, which tries to set the Review's recommendations in the context of the whole school, will appear at the same time as the Guides. These will, when taken with earlier and forthcoming SSCR publications, including those from local groups, constitute the recommendations which the Review is making towards a broad and balanced science education for all the young people in our schools. The series title, 'Better Science' is thus both apposite and self-explanatory. It is hoped that the current phase of the Review (1986–89) will achieve successful imple-mentation of the recommendations.

But what is the status of these new publications apart from reflecting the formal approval and support of our major sponsors, the School Curriculum Development Committee and the Association for Science Education? From what sources have the recommendations within them emanated? Those readers unfamiliar with the history of the SSCR will find it explained within the Guides; but most will be aware that it set out as a project which tried fully to involve the practising teacher in the development of solutions to the problem of science for all. Thus, although the Guides have been compiled principally by the Central Team of the Review, they draw on the work of thousands of teachers in working groups over the past four years. Although the work of many of the groups is referred to in the Guides, it is not possible to refer to it all. In the *Directory of Resources* readers will find details of what many of these groups have produced. The writing of these Guides, however, would not have been possible without the groups' existence and the Review Central Team hopes that the content of the Guides truly reflects their work. Thus the pronoun 'we', used within them, often reflects the view, gleaned over five years of consultation, of the practising teachers involved with the Review. On other occasions it can represent the views of the SSCR as constituted by the Central Team and Steering Committee and it is hoped that particular usage will be apparent from the context.

Jeff Kirkham
Mick Michell
Jeff Thompson
Dick West
(SSCR Curriculum Guide Editors)

Introduction

Who has special educational needs?

The Report of the Warnock Committee gave recognition to a new view of special education which, rather than categorising young people and focusing on their disabilities, emphasises the need to provide access to the curriculum by identifying and meeting individual special educational needs. In this Curriculum Guide, we examine the implications for science teachers from this change in emphasis and concern ourselves in particular with students in mainstream schools with mild and moderate learning difficulties. We draw on the experience of teachers in both special and mainstream schools to describe some of the strategies which enable access to the science curriculum and to demonstrate the powerful contribution which science can make to the overall education of these young people.

Consider the kinds of abilities and aptitudes which would make learning in science lessons easy for a youngster newly arrived in secondary school. Your list might contain some or more of the following:

- Able to read and write well
- Highly motivated to learn
- Finds it easy to express her/himself
- Gets on well with peers
- Finds it easy to concentrate on the task at hand
- Ready and willing to work with the teacher
- Has good mathematical skills
- Is physically well-coordinated
- Willing to 'have a go'
- Able to use all senses effectively to make observations.

Young people possessing all these attributes have a head start in achieving success in science, no matter what the learning environment. For most students, some qualities will be less developed than others but, given an environment which encourages learning, growth will occur. Some students, however, will have difficulties which present a barrier to learning and may prevent them realising their full potential. The policy of science for all, coupled with the notion of minimum entitlement, means that rather than excluding students with learning difficulties, as may have been the case in the past, the onus is placed on us to develop the means whereby young people can gain access to that science education which we now define as a right and a necessity. Entitlement has been defined in **Choosing content** and does not require restatement here. This Curriculum Guide is about access. How can we adjust and adapt the way that science is presented to meet the needs of all young people and not just those with a full hand of those skills and attitudes listed earlier?

Science teachers are increasingly aware of students who have learning difficulties. During recent years, many have been involved in curriculum development in order to determine more appropriate provision for these students. Recommendations, curriculum materials and assessment procedures have been produced which refer to:

- Pupils with low educational achievement
- Less-able pupils
- Low-attainers in science
- Slow learners.

Often such initiatives did not make explicit their underlying assumptions about entitlement. They tended to be targeted on the 14–16 year old student and content selection was dictated by ideas of relevance and usefulness. Learning difficulties were not neglected in such schemes; 'motivating the poorly motivated' was a central plank, reading difficulties were acknowledged and mathematical and manipulative demands were kept to a minimum. These developments reflected a perfectly proper set of concerns: how best to engage a group of young people, many of whom are disenchanted with schools and schooling and some of whom are lacking in those skills of literacy and numeracy essential to much conventional learning in science? The maintenance of order and discipline in busy classrooms and laboratories remained an accompanying anxiety for many teachers and fuelled the demand for new schemes and strategies. Indeed, many SSCR groups took on such tasks and identified the students for whom the materials were intended using the labels already quoted.

However, there are hazards associated with this labelling and categorisation of students. By apparently addressing the needs of the many, we can place at risk the requirements of the few. Able but ill-motivated students may require different means of access to science than others in their peer group who are well motivated but have marked learning difficulties, be they intellectual, social, sensory or physical.

Such considerations suggest that approaches which focus on the learning difficulties of individual students rather than the apparent characteristics of groups may well merit our attention. This notion has been given additional impetus by the publication in 1978 of the Warnock Report (**0.1**). This report has at its heart the notion of abandoning categories of disability. It offers in

their place the concept of 'special educational need'. It is of relevance and importance to teachers of science in all schools and refers not only to those young people defined formerly as handicapped, as the following quotation demonstrates:

> *Our conclusion that up to one child in five is likely to need special educational provision in the course of his school career does not mean that up to one in five is likely to be handicapped in the traditional sense of the term. The majority will be unlikely to have such a long-term disability or disorder. Their learning problems, which may last for varying periods of time, will stem from a variety of causes. But unless suitable help is forthcoming, their problems will be reinforced by prolonged experience of failure. We refer to the group of children – this one in five – who are likely to require some form of special educational provision at some time during their school career as 'children with special educational needs'.*
>
> (The Warnock Report, 1978)

The Warnock Report and the subsequent 1981 Education Act focus on the educational needs of students rather than the disabilities and difficulties which create such needs. At the same time, the definition of special education has been broadened to encompass many young people already in mainstream schools. It is also worth noting that many students formerly catered for in special schools are now appearing in the classrooms and laboratories of mainstream schools.

This publication therefore reflects the Warnock Report in that it is based on the notion of *identifying and responding to individual educational needs*. In particular we look at how that minimum entitlement to science education noted earlier can be realised. It seems clear that many conventional courses provide only a partial solution. What is equally clear is that detailed prescriptions are not possible given the requirement for a response to individual needs. No scheme or set of curriculum materials can hope to meet such needs without what Brennan (**0.2**) calls:

> *that intimacy of knowledge on the part of the teacher. Knowledge about the pupils' home and neighbourhood background: about his or her patterns of motivation, interests and learning potential: about health and physical status: about current special needs and the way they may develop: all these may be related to existing and potential facilities and professional skills in reaching decisions about curriculum. The intimacy of knowledge possibly exists only within the pupil's school through continuous contact . . . by sensitive teachers.*

Thus our task is to indicate some key principles which might form the basis for decisions about the science provision to be made. It is very difficult for any publication to address the whole spectrum of special educational needs. We run the risk of either focusing on those young people with pronounced learning difficulties to the exclusion of all others, or we risk the charge of superficiality by trying to group all young people under the one convenient heading.

Our major concern is with students with **mild and moderate learning difficulties**. We choose these students since their learning difficulties are the most common source of special educational need in mainstream schools. The 'thumb' sketches on the opposite page may help to remind us of the students we are talking about.

Relatively little is said about that important group of students who bring a range of physical, sensory and more marked mental/intellectual handicaps to challenge our teaching and learning system. Details of such specific provision are beyond the scope of this Curriculum Guide, although some examples of teaching physically handicapped young people can be found within the case study in Section 3.

Purposes of science education

We have already argued that in this Curriculum Guide we should not be concerned with defining courses and content (although other Curriculum Guides are useful in this context). It is worth reminding ourselves, however, of those broad aims for science education for all students which ought to give us particular concern when seeking to meet the needs of students like Paul, Maria, Tony and Lisa. These aims include:

- assisting them to develop a better understanding of the world they live in;
- encouraging the development of their communication skills;
- enabling them to improve their personal relationships;
- helping them to be better able to solve their own problems.

The specific skills, attitudes and processes that we should be aiming to develop are detailed in **Better Science: Choosing content**, another guide in this compendium. This content guide also lists those areas of science in which young people should be given opportunities to develop their own ideas.

Lisa helps with looking after the animals and is always first to lessons. Conversation with her is exhausting since she offers no word on her own initiative. She is introverted with peers and is immature for her age. She attaches great importance to the presentation of her work and if allowed would prefer to sit and write up notes or copy up work rather than be involved in practical work. She lacks self-confidence and needs constant assurance that the work she is doing is correct.

Paul is a very witty and gregarious 14 year old. He is one of the main contributors at class question time and is quick to spot patterns and interpret data from experiments. He is very mechanically minded, which has been an asset when you've been having problems with the audiovisual equipment. He is often on the scene when staff are having problems with their cars. However, he does little in the way of written work and avoids handing in his book to you. He is withdrawn for extra help with his writing and reading for part of his timetable but prefers that you don't mention that. You know that he is capable of understanding science ideas which go beyond the work that you do in class but his reading is very poor and he steers clear of textbooks.

Tony loves science. He bounces into the lab and is always keen to know what the prospect for the lesson is. He will pick up, fiddle with, pour away or take to pieces anything left in the lab. He cannot sustain concentration, nor follow instructions for long and will invent his own version of the experiment. He is a source of danger, having scorched other people's belongings, been found with a pool of mercury in his hand and been caught practising deft strokes with a scalpel behind someone's head – copying something he saw on television. He also asks for homework.

Maria reads and writes well and gets on with individual written work. There are problems in practical work though since she doesn't seem able to work with any of her peers. She is extremely competitive and has to be first in the queue for everything. There are big problems when she doesn't get the biggest or best piece of apparatus and her aggressiveness has been the cause of several scenes. Science lessons aren't the only place that she has problems with people and she has already been suspended from school.

A further consideration that may be even more important than those given above has been expressed by Carroll Nicholl, an SSCR coordinator in Northern Ireland:

> *any programme of work in any subject area which does not provide the pupils with enhancement in self-esteem is unlikely to succeed. Self-esteem is built upon success and good interpersonal relationships and it is fostered by cooperation rather than competition. Science provides an excellent context through a practical, problem-solving approach for the development of co-operative attitudes and hence natural self-esteem can increase.*

As teachers of science who have studied our subject in depth, it is perhaps difficult to stand outside our own experience and consider the kinds of experiences which will enhance self-esteem in the young people in question. Although our aims may be the same, it will mean that our objectives carry different priorities or may be more limited. For Maria, the girl with social problems, this could mean that we would view 'getting on with her partner in practicals' as our primary objective before we consider 'improving manipulative or writing skills', or 'making sure she has a working understanding of the term "energy"'.

Overview of the publication

This publication is about identifying and responding to learning difficulties.

Section 1 considers current practice and the lessons which we can learn with respect to future provision.

Section 2 draws upon the work of SSCR groups and others with respect to the identification of learning difficulties.

Section 3 is in the form of a case study which describes the moves that have been made in two schools to provide access to science education for young people with special needs.

Section 4 lays out some general principles for teachers to consider when developing their own strategies to give access to science education for young people with learning difficulties.

Further reading presents a list of additional written and other sources of information in the field.

No single written publication can hope to record the range of classroom techniques practised by the teachers involved in curriculum change. Therefore, to extend the coverage of this publication, we are producing a video and workshop pack which describes some of these changes (details in *Further reading*).

Finally, it is perhaps worth saying that the proposals we make may be controversial and a few will challenge even the most experienced of our readers. We do not pretend that any of our suggestions are easy to implement nor that they achieve change overnight. However, we have worked with many teachers who feel that by changing their practice in the ways which we describe they have extended the educational opportunities they offer for young people with special educational needs. The benefits can be enormous, as one teacher enthusiastically describes:

> *Practical investigations appeal to all children. In my integrated and rural science lessons, the success that pupils with learning difficulties have experienced have been a joy to see. Seeds do germinate, plants do grow and are admired or harvested, photographs are taken and successfully developed, eggs do hatch, material does look good when dyed, the school environment does look better and is admired as a result of their hard work and from their practical experiences, science is learned, their self image is improved, behaviour correspondingly improves and so do their written and communication skills.*

SECTION ONE

Meeting needs: reviewing current practice

In this section, we look at some reviews of current practice which we hope will provide the background for the proposals we make in subsequent sections. The data we use has been collected from a variety of sources including SSCR groups (Box 1).

1 General points about current science provision for those with special needs arising from local and national surveys.
2 Issues which arise out of evaluation of existing curriculum materials.
3 Data collected by the Assessment of Performance Unit (APU) about students' capabilities.

Box 1 *Three aspects of current provision*

Current science provision

This account is based on two recent surveys of science provision. The first was carried out within Essex by an SSCR group to find out about existing science provision for young people with learning difficulties in mainstream schools (*Science for the lower attaining pupil*). The second survey was carried out by HM Inspectors (**1.1**) and was an investigation into provision for science education in special schools and units.

A local survey

The Essex SSCR group carried out a survey of provision for fourth and fifth year 'low attainers' in eighty of the local education authority's schools. Their definition of low attainers included students who would be recognised as having mild learning difficulties. They found that provision was very mixed, with the majority of pupils in CSE examination classes or mixed target examination classes following courses such as:

1 traditional physics, chemistry and biology options
2 modular science
3 agriculture/rural science
4 integrated/general science
5 environmental science
6 human biology
7 technology/electronics/engineering courses.

A quarter of the schools ran separate non-examination classes.

Most schools incorporated curriculum materials from development projects for low-attainers such as *Science at Work* (**1.2**), *Open Science* (**1.3**) and *LAMP* (Less Academically Motivated Pupils) (**1.4**).

Some schools provided leaving certificates for their students, although the most common type of record of achievement at school was the student's examination results listed on a confidential report to potential employers. In its proposals for the future, the group questions the appropriateness of the examination-oriented option system which they found to be common practice in most schools. The group felt that students should follow:

> *a broader curriculum with no specialisation [and that] many pupils might achieve more in a non-examination situation where the pressures of 'covering the syllabus' are removed . . . such pupils need greater flexibility in teaching/learning situations, which examinations, rightly or wrongly tend to suppress.*

While agreeing in principle with this, we would point out that any new courses which are developed still require a clear statement of objectives and goals as well as proposals for assessment which record individual progress and achievement.

A national survey of special schools and units

Poor provision for science education is common in special schools and units and is recorded in a recent HMI survey (**1.1**). Inspectors visited special education establishments which were known to have some provision for science. Even so, they found few schools which provided a satisfactory curriculum. The facilities were generally poor and few schools had written schemes of work or guidelines for science. Although acknowledging that many schools engaged pupils in practical science activities, the Inspectors point out that:

> *The activities were often confirmatory exercises emphasising manipulative skills and the pupils were not encouraged to think and operate scientifically.*

A particular disappointment was 'the low level or even lack of involvement of the science teacher in the ordinary schools with the work of special education units attached to ordinary schools.'

The shortcomings of much current practice identified by these surveys provide us with an agenda for change. We suggest:

- provision of a broader science curriculum;
- the need for different forms of fostering, recognising and recording achievements;
- more varied teaching and learning approaches;
- a greater emphasis on 'working scientifically'; that is a more open, process-based curriculum.

It was concerns similar to these which stimulated considerable SSCR work in this field.

Evaluating existing curriculum materials

A look at the published schemes which are available suggests that youngsters have to wait until the fourth and fifth years to have access to a more individual response to their difficulties. Texts for lower school science are rarely linked to ability, whereas material for the 13–16 group carry labels such as 'O-level text' or 'materials suitable for non-examination classes'.

The Avon *Half our Children* group (**1.5**) developed a tool to evaluate these existing materials which would help them to identify the strengths and weaknesses of the courses they were currently providing. They have worked on a framework for science courses which includes:

1 A detailed breakdown of skills which all students should have the opportunity to acquire arranged in seven groups (see Box 2).
2 Areas of experience to which students should have access during a science course (see Box 3).

The group then used this framework to evaluate some of their existing published courses and drafted a *Which* report of their findings. Reading this draft, one can identify many similarities between published courses. For example they tend to:

Abbreviated skills framework

All . . .
Most . . .
Some students should be able to . . .

1 Manipulative skills

- assemble three-dimensional shapes
- use a small electrical screwdriver; wire a mains plug; set up an electrical circuit
- manipulate basic science equipment
- carry out sorting exercises
- transfer material from a mortar; hot liquids out of a beaker
- cut shapes from paper or card
  - handle animals and plants with care

2 Observation skills

- match coloured substances to reference colours or standards
- classify substances into one of three states of matter
- match an object with a variety of visual representations
- identify hazardous situations
- listen and watch carefully
  - describe changes of colour and state
  - match and identify fine differences between similar objects
  - classify objects from given information
  - recognise scientific and technological artefacts

3 Communication skills

- read information from pictorial displays
- plot information onto partially completed graphs, pie charts, etc.
- copy written information
- record simple information read out by another person
- follow and act upon instructions presented diagrammatically
- listen to others
- obtain information from a variety of sources
- compare and classify two items
  - communicate information and ideas by appropriate means
  - record observations accurately given appropriate headings
  - plot information onto graphs, pie charts, etc. given appropriate scales and axes
  - set out work simply and neatly in a personal style within a structured format
  - follow and act upon instructions given verbally or in writing
  - make a brief oral summary of presented information
  - compare and classify more than two items
  - observe and describe changes in colour, in form and in level
  - use appropriate units, symbols and abbreviations in both oral and written work
    - plot information onto graphs, pie charts, etc., without given scales and axes
    - use appropriate scientific language

All . . .
Most . . .
Some students should be able to . . .

4 Measurement skills

- use correctly standard laboratory measuring equipment
- read a digital meter
- read an analogue scale
- make measurements that involve the use of a container
- make estimates of the quantities being measured
  - use dual scale meters and eyepiece scale correctly
  - interpolate between divisions on an analogue scale
  - be able to use a tare
    - use vernier calipers/micrometer correctly

5 Experimental skills

- design experiments in outline to test ideas
- perform all aspects of experimental work safely
- select appropriate apparatus
- select appropriate measuring instruments
- assemble apparatus from a printed diagram and verbal instructions
- test hypotheses
- draw conclusions from experimental results
- record all measurements correctly
  - produce complete experimental designs
  - appreciate the sensitivity of measurements
  - see the need for control experiments
  - make predictions
  - apply knowledge and experimental skills to familiar situations
  - formulate hypotheses
  - correct faults in experimental apparatus
  - use a key
    - have a more detailed understanding of experimental accuracy
    - set up control experiments
    - apply knowledge and experimental skills to unfamiliar situations

6 Social skills

- work with others as a team
- develop self confidence and self control
- discuss and listen to arguments
- develop concern for the environment
- be honest in work and in social interactions
- show flexibility, initiative and perseverance

7 Study skills

- copy and record simple information
- arrange information in a table and use an index
- ask questions of the teacher and of others
  - memorise and recall facts
  - use basic examination techniques effectively
  - learn to use time effectively
    - learn to prepare for examinations

Box 2

- be organised into short theme units rather than as a whole textbook;
- be rooted in the applications of science;
- involve a lot of practical activity;
- be very prescriptive with respect to what pupils should do;
- lack real problem solving;
- give little opportunity for pupils to describe their experience and express themselves.

Having developed these checklists, the group then invited local teachers to analyse their own courses. Significantly almost all teachers felt that they would modify the curriculum on offer.

Activity	Aim	Example
Field work	To experience science activities outside the confines of a laboratory	Residential, day or part-day visits (e.g. natural history, industrial visits)
Social implications of science	To investigate media presentation of scientific information. To encourage objective analysis of such information	Pollution (e.g. fertilisers, insecticides, nuclear power, test-tube babies)
Questioning an expert	To be able to prepare and ask relevant questions communicate with strangers and obtain the desired information	The local vet (pet care); health visitor (child care)
Making a tangible product	To coordinate important skills during the production of a specified end product	Model-making

Box 3

Modification of current provision was also suggested by the work of the Durham SSCR group *Science Education for Children with Learning Difficulties* which concentrated on the *Science at Work* materials used in two-thirds of the schools in the local education authority. The group's review of the material with respect to the aims of the SSCR suggest that improvements are required. These include:

- the need for opportunities for experimental design and problem solving;
- the inclusion of opportunities to design and develop solutions to technological problems;
- more attention to the historical background and cultural significance of science;
- more opportunity for students to discuss, reflect upon and evaluate scientific concepts and theories;
- activities which involve evaluating data in different ways.

There can be no doubt that the *Science at Work* materials, like other similar materials, represent a major advance in providing for students with learning difficulties. However, as the SSCR groups have demonstrated, there are shortcomings. The moves to emphasise the processes and skills of science mean that, although still very useful resources, these materials need to be supplemented. How this might be achieved is discussed in subsequent sections.

Concurrent with the SSCR groups' evaluation of curriculum materials, the Association for Science Education (ASE) set up a working party to review their own *LAMP* publications. Significantly, the working party have recommended to the Association that these publications be discontinued since:

> *In particular there was felt to be insufficient emphasis on problem-solving activities, on the processes of science and on the need to ensure pupils gain experience of all the major areas of science*
>
> (John Bowers, General Editor of the LAMP Project in *Education in Science*, June 1986)

What can students do? Learning from APU findings

In the Introduction we pointed out that it was important for science education to enhance a student's self-esteem. This suggests that there ought to be a match between the science activities we provide and the abilities of the students. Our expectations of students will be reflected in the objectives we set them. As was pointed out in the HMI secondary survey (**1.6**) published in 1979:

> *. . . pupils including the least able . . . usually fulfilled the expectations of their teachers.*

The findings of the Assessment of Performance Unit (APU) reflect the successes and failures of youngsters across the whole spectrum of the school population, so extrapolation with respect to those with learning difficulties is done with reservation. However, a comparison of the objectives underlying the existing schemes with the findings of the APU give some food for thought. Consider the match, or mismatch, in the pairs of statements in Box 4.

We would argue that these mismatches do little to alleviate the problem of low self-esteem amongst children with learning difficulties. The APU survey suggests that most youngsters are able to design experiments and handle data. Shouldn't we be using this as a way of helping to enhance their self-esteem by giving them the chance to show what they *can* do? If they revert to 'common sense notions' rather than apply taught science ideas, shouldn't we be allowing them to discuss such notions in class and try them out to

1 *experimental design is not included in* [Science at Work] *material* (Durham SSCR group)

Where questions were set in familiar contexts, then the majority of pupils are able to draw inferences or undertake an experimental design (APU report at age 15, 1981)

2 *It was felt that more varied activities would be an improvement. The activities could include data to evaluate in different ways, pictorial information etc.* (Durham SSCR group)

Nearly all pupils read off information from line graphs, bar charts and tables with reasonable accuracy (APU report at age 15, 1984)

3 *To develop the ability to apply knowledge. To understand and recall factual material.* (objectives for *Science at Work* materials)

In responding to conceptual problems set in everyday contexts, there was a tendency for pupils to base their responses on 'common sense' as opposed to taught science ideas. (APU report at age 15, 1984)

4 All schemes evaluated by the Avon *Half our Children* group had units on basic electricity.

only a fifth of pupils or fewer can either draw a circuit diagram or set up a circuit to match such a diagram . . . about two-thirds can connect a circuit to match a photograph (APU report on electricity at age 15)

Box 4 *Comparison of APU findings and statements from elsewhere*

see if they work, rather than expecting them to absorb ideas which they do not understand and cannot apply?

In the secondary survey (**1.6**), HMI state that:

It was the work of the less able, whatever the type of school, which gave greatest cause for concern.

This was still true in 1985 (**1.7**) when HMI judged that only three-fifths of the lessons for the least able which they observed were satisfactory or better. However, where teacher expectations were high, such youngsters

showed a good level of practical laboratory skills, the ability to work independently and willingness to speculate when new situations were presented to them. **(1.6)**

What are *your* expectations of these young people? Do they encourage or limit their development in science?

Considering your own provision

In this section we have emphasised the weaknesses of current provision by way of setting out a rationale for the proposals we make in later sections. In Box 5 we lay out a checklist of questions which arise out of what we have written so far and which may assist you in structuring your own analysis of current practice within your own school.

1 What science courses do students with learning difficulties follow? Do they provide a broad or a specialised curriculum?
2 What are the objectives and goals of the current science curriculum and are they appropriate for those with learning difficulties?
3 In what ways does current practice encourage the development of self-esteem?
4 List the teaching and learning strategies currently employed. Do they include opportunities for youngsters to:
   - design experiments?
   - design and develop solutions to technological problems?
   - discuss and reflect upon their own ideas about science?
   - describe their experiences and express themselves?
   - evaluate data in different ways?
5 Which skills and processes are developed by resource materials currently in use? (Use of the Avon skills list may be helpful in this context.)
6 What forms of assessment are currently in use? In what ways do they encourage students to demonstrate their strengths as well as their weaknesses?
7 How are young people with learning difficulties identified and how is 'special provision' provided in the context of science?
8 What arrangements are made to ensure the interchange of knowledge and expertise between science departments and special needs departments/units?

Box 5 *A checklist for analysis of current practice*

The following sections are framed by such questions and draw upon the work of teachers who found weaknesses in existing provision and who have attempted to develop new approaches to teaching young people with learning difficulties.

SECTION TWO

Identifying the needs of individuals

Introduction

Getting to know an individual student, picking up the clues about his or her interests, worries and difficulties is part of our day to day activities as teachers. A mark of our professionalism is our ability to respond to such clues so that we can maximise the learning which takes place. This 'intimacy of knowledge' is drawn upon many times every day even though we may not be aware of it. For example:

- using Sam's interest in gymnastics to demonstrate muscle action;
- remembering that Germet stutters when speaking to large groups so giving him practice with an audience of three;
- reminding Sally of the magnificient display work she managed on the last field trip, so why is she not maintaining her standards?

Much of this knowledge comes from the interaction between teacher and student in their timetabled lessons, but other sources also play an essential part. This section will examine some of the ways in which we might gain more information about the needs of youngsters with learning difficulties so that we might improve their access to the science education we offer them.

Some sources of information open to us are listed below:

- Primary/middle school staff
- Parents
- The student her/himself
- Special needs/remedial department
- Your observations/experiences of the youngster
- Formal tests and other assessments
- Form tutor/year head
- Other subject teachers.

Using these information sources is nothing new, but can we develop a more systematic approach? Are there any ways in which we might be more analytical about individual youngsters without losing sight of their individual complexity? Groups working on profiling and records of achievement have drawn our attention to some of the strategies we might adopt. A closer examination of the principles involved in profiling is presented in more detail in **Better Science: Assessing progress** so this section looks specifically at how a science department might collect information about an individual's learning difficulties in the early stages of their secondary education. As a means of informing both present practice and teaching and learning in the future, 'catch them young' is perhaps a useful adage.

Obviously acquiring knowledge from the sources listed above will be affected by the organisation of individual schools, but there are

Previous progress in primary and middle school education

1 What kinds of information are supplied by the feeder schools?
2 How can we best use this information for the benefit of those with special needs?
3 What are the drawbacks of using the information?
4 How might we improve the quality of the information?

Information from other sources

1 What mechanisms are available for listening to parents? Are they adequate?
2 What information could remedial or special needs departments supply which would help us to respond to individual students?
3 How is information about a student's special educational needs transmitted in school?
4 What are the lines of communication between science staff and individual form tutors and year heads?
5 Is effective use made of other sources of information and expertise – Educational Welfare Officers, and Educational Psychologists for example?

Planning the curriculum to facilitate information gathering

1 Do our teaching approaches allow us the opportunity to collect information about how individual students learn?
2 How might we organise the curriculum to enable us to pick up clues about learning difficulties as soon as possible?

Collecting information from individual students

1 What methods for student self-assessment are possible?
2 Are the current methods of recording progress of individuals adequate? If not, how can they be improved?
3 How do we find out what their interests and aspirations are?
4 What strategies do we have for finding out about their worries and difficulties?

Box 6 Checklist of questions regarding collection of information

some basic questions which arise out of the list we have given. For example, members of a science department might use a checklist like the one in Box 6 when faced with a new intake of yougsters. This is not a definitive checklist by any means, but is structured in this way so as to highlight the fact that there is a considerable amount of information about individuals which is already available before they enter secondary school. The Essex group point out in their report that many of the young people whom they called 'low-achievers' in the fifth year could have been identified as having difficulties on entry at age 11. Therefore perhaps our first main concern is how best to utilize this existing information.

Having posed the questions, the rest of this section is devoted to describing some of the strategies that groups have developed in an attempt to address them.

Previous progress in primary and middle school education

1 What kinds of information are supplied by the feeder schools?
2 How can we best use this information for the benefit of those with special needs?
3 What are the drawbacks of using the information?
4 How might we improve the quality of the information?

Establishing effective links with feeder primary schools has been an aim of several SSCR groups. The nature of such links is obviously geared to the local situation (see **Better Science: Building primary-secondary links**). However, information gathering about individual youngsters is usually of prime importance. A Croydon SSCR group, for example, started looking at information transfer for the purposes of documenting the skills and processes with a view to developing individual pupil profiles, noting that:

> *We feel the need for a pupil profile which runs from the infant school through to the final year of secondary school. The profile need not be subject specific but should list a series of process skills arranged in levels, each stage being identified by selected specified criteria. Each stage should be ticked and dated.*

How might such a profile be constructed? A number of initiatives to bring together feeder primary schools and secondary schools have been set up for whole-curriculum discussions. Creation of profiles might be achieved in this way. While agreeing that this approach could encourage continuity and progression for all youngsters, we caution against the total acceptance of such records. Not only is secondary school a chance to 'have a fresh start', but we ought to beware of 'self-fulfilling prophesies'.

Although information on paper is very useful, a science department might also consider 'finding out' through exchange visits to feeder primary schools as the Leicestershire *'10 +'* group did. For example, one secondary school timetabled visits to feeder schools on a weekly basis so that science teachers could both observe and take lessons, thereby getting to know staff and pupils. There are obvious difficulties here depending on the number of feeder schools, however such early contacts with youngsters can bring benefits, as one of the secondary school members of the group reports:

> *the observations made at the primary schools have led to a complete revision of the First Year Science Curriculum for 1985–86 and consequent but less complete alterations to the second and third year courses. It had become abundantly clear that our expectations of the acquired skills of new pupils were not only wildly optimistic, but did not take into account the variation in the experiences of the pupils.* **(2.1)**

Information from other sources

1 What mechanisms are available for listening to parents? Are they adequate?
2 What information could remedial or special needs departments supply which would help us to respond to individual youngsters?
3 How is information about a student's special educational needs transmitted in school?
4 What are the lines of communication between science staff and individual form tutors and year heads?
5 Is effective use made of other external sources of information and expertise – Educational Welfare Officers and Educational Psychologists for example?

We do not attempt to deal in any detail with the many other sources of information potentially of value in identifying and, in some instances, meeting the needs of individual young people. (Educational Psychologists, for example, have clear expertise in diagnosing learning difficulties and in suggesting programmes of remediation.) There will as ever be marked variation in local practice and provision between schools. The important message is that there are other individuals and agencies which can contribute significantly to painting the 'needs picture' for

Paul, Maria and others. The question for us as science teachers is, 'do we both recognise and make use, as far as is practicable, of such other sources?' Teachers with whole-school responsibility for students with special educational needs are likely to have detailed information about students with reading and numeracy difficulties, for example. They may also have a greater 'intimacy of knowledge' of some youngsters since they have had more individual contact with them, unlike the science teacher who may see such individuals for only two or three lessons a week.

To aid communication, collation and dissemination of appropriate information, a number of science departments have assigned specific responsibility for the 'special needs area' to an individual science teacher. She/he as part of that role liaises with the school-based special needs staff or remedial departments and enables effective cooperation and the sharing of expertise. However, this kind of organisation must be carefully managed and the role of such a person needs to be clearly defined, to ensure effective liaison between *all* members of the science department and the special needs specialists. Otherwise one person ends up acting as the 'conscience' of the whole department when in fact it is the responsibility of individual science techers to ensure appropriate provision for students in their charge. All members of the science department can learn a great deal about approaches to reading, introduction of new words, writing appropriate curriculum materials, etc., from special needs colleagues who may, for example, be invited to join school-focused in-service work to share their knowledge and expertise.

Planning the curriculum to facilitate information gathering

1 Do our teaching approaches allow us the opportunity to collect information about how individual students learn?
2 How might we organise the curriculum to enable us to pick up clues about learning difficulties as soon as possible?

Finding out about the abilities of pupils on entry to secondary schools has always been a priority. For some schools it has been for the purpose of organising teaching groups in sets or bands. However, even where groups are to be organised along mixed ability lines, there is much to be said for giving priority in this initial period to finding out as much as possible about what skills and knowledge the students bring and to identifying the significient shortfalls in their learning toolkit.

Finding out where youngsters are with respect to their skills on entry to their new school has been a priority for the Hampshire Special Education group who recall:

> *What we set out to achieve, was the production of some introductory lessons, the purpose of which would be to enable the teacher to make some kind of initial assessment of the pupils. At first we had high hopes of being able to complete a checklist of key skills for each child, although the need to manage the lesson and to establish a relationship with the children meant that we had to settle for making a rough assessment of the group as a whole. In other words, we would begin with a lesson requiring minimal leadership and intervention on the part of the teacher, in order that the children could be observed using some of the skills that they had already mastered elsewhere.* **(2.2)**

This then is a teaching approach deliberately freeing the teacher to allow her/him space and time to make careful observations (see also the SSCR Curriculum Guide **Better Science: Approaches to teaching and learning**. If such an approach is adopted, it is clearly important that the science department are agreed about the skills they see as being required for effective learning in science. Diagnosis can, with judgement and luck, lead to appropriate interventions in order to help the individuals concerned. Take for example a group of students with moderate learning difficulties who were observed carrying out an investigation to find out the best way of keeping water as cold as possible:

> *All six pairs had spent time talking about their ideas and were ready to test them. Martin and Brian placed their three containers in different places around the school but their problems arose when they had to compare the temperatures . . . they didn't know how to read a thermometer. However, because they were involved in the experiment they were motivated to want to find out and teacher was able to intervene to provide suitable reinforcement in reading scales.*

Returning to establishing an agreed framework of 'necessary skills', the Hants Special Needs group offer the following lists of skills (although perhaps 'attributes' may be a more all-embracing term) required in science which they organise under two headings: firstly, the general skills which are seen as important for any lesson:

- Cooperation
- Perseverence
- Curiosity
- Responsibility
- Observation
- Communication
- Following instructions
- Long-term and short-term memory.

And secondly, those skills seen as having special relevance in science:

- Manipulating
- Estimating
- Measuring
- Recording
- Classifying
- Raising questions
- Predicting
- Solving problems.

Having decided on the skills, the next task is to agree the 'baseline' for each skill so that a teacher can gain some idea of where each individual is and thus be aware of where difficulties might arise in the future. For example, if youngsters are to be working on investigations related to the effects of electromagnets, they will need to be able to set up a circuit. If they are to use written instructions it will be important that worksheet or text can be read and so on. Skill identification, agreeing baselines and methods of diagnosis are thus important. We hope that teachers do not think that we are suggesting that each individual is put through a bank of tests to find out their level. Rather that, by having a checklist of skills, the teacher has some guide to help them recognise a student's strengths and weaknesses. Establishing where youngsters are with respect to a particular skill may be the main objective of a lesson as it was for this one on 'listening' described by the Hants *Special Needs* group (**2.2**):

> *A poem on Noise by J. Pope was used to draw the children into discussion about various sounds. The children were then asked what sounds they could hear while sitting with their eyes closed for thirty seconds. A list of the sounds was then compiled, most notably at this instance, a tractor outside, a class working next door and a girl crying.*
>
> *The whole class then went to another area of the school and again listened for thirty seconds. Back in the classroom, the teacher helped the pupils to record what they heard by drawing up a simple chart. Discussion followed automatically about the quality of the different sounds.*

This activity is specifically designed to practise listening and the teacher can then note the different skill levels within a group. After several lessons, students with particular difficulties can be identified and strategies developed to help them to sharpen their skills.

The above suggestions focus on information gathering in the early stages of a youngster's secondary career, but similar strategies can be employed whenever a new unit of work is about to be undertaken. For each unit of work, a department can identify not only the skills which they hope to develop and improve, but also the assumptions that they are making with respect to the skills the youngster needs to have already. For example in order to tackle investigations on heat, a department might list the following requirements or 'entry skills':

- able to read a thermometer;
- knows the names of the apparatus on the instruction sheets;
- is aware of the idea of 'fair tests';
- able to record results in a table;
- able to work safely with hot apparatus, etc.

This is not to suggest that the lead up lessons to this topic consist of practising the skills 'because you'll need them when we do more interesting things'. (Indeed we would not favour such an approach since it removes the skill from a context and a student may not see any point to such an activity.) However, such a list does highlight areas of possible difficulty so that remedial activities can be at hand if and when problems arise. It also brings to mind that it may be a year since the thermometers were used and therefore perhaps some opportunities to use them without too much other apparatus around might be an idea before launching into the more complex activities.

Collecting information from individual students

1. What methods for student-assessment are possible?
2. Are the current methods of recording progress of individuals adequate? If not, how can they be improved?
3. How do we find out about the interests and aspirations of our students?
4. What strategies do we have for finding out about their worries and difficulties?

Listening to rather than talking at might be an appropriate label for such approaches and should be part of our teaching toolkit. Perhaps it seems too obvious to point out that young people themselves are potentially our most fruitful source of information. Although they might have difficulty in articulating their difficulties or the reasons for them, they are the ones who know that they worry about their inability to read a worksheet or the fact that they still cannot focus a microscope after all this time. They may not find it very easy to admit these worries and difficulties but by looking for strategies which might help them to do so, we might unlock this most useful source of information.

Most of us would applaud such aspirations but with a largish teaching group whom we might

meet only two or three times a week, is it possible? The notion of self-assessment using a pupil profile is a method recommended by a number of SSCR groups. For example, the Hereford and Worcester assessment group (A pilot scheme for profiling of science related abilities of the 13–14 age group) points out that:

> *The use of the profile is intended to encourage pupils to be aware of the skills and abilities that they should aim to develop during a particular course and to reinforce their responsibilities for their own learning. It should provide a useful feedback on individual pupils' learning difficulties and act as a checklist for the development of a course.*

The group has structured a checklist to identify the skills so that each pupil can check her/his own progress. Achievement of the objectives is recorded by the signature of both student and teacher against the appropriate statement. One section of their checklist is reproduced in Box 7.

Mathematics in Science skills	Pupil	Teacher	Date
1 Can correctly add and subtract whole numbers up to 100.			
2 Can multiply together two whole numbers each less than 100.			
3 Can correctly divide two whole numbers.			
4 Can calculate the 'average' of a list of numbers.			
5 Can multiply or divide by 10,100 or 1000 without using a calculator.			
6 Can calculate the area of (a) a rectangle (b) a circle given the formula.			
7 Can find the volume of (a) a cube (b) a cylinder.			
8 Can change simple fractions into decimals and vice versa.			
9 Can use a table for conversion of units (cm – inches).			
10 Can understand (a) a bar chart (b) a graph.			
11 Can draw (a) a bar chart (b) a graph.			
12 Can find the gradient (slope) of a straight line graph.			
13 Can correctly round off a long number (3·647812) to 2 decimal places.			
14 Can use a calculator for: (+)(−)(×)(−) without error.			
15 Can change a formula such as $x = ay$ so that only y is on the left-hand side.			

Box 7 *A skills checklist*

It must be pointed out that the profile given in Box 7 has been designed for a whole year group. It may therefore be a rather blunt instrument for collecting information about the 20% of individuals identified as having special educational needs. Also, using the same profiling lists for all students, though administratively easier, may unnecessarily threaten those who, despite a great deal of effort, still do not get many signatures. There will also be concern about demanding too many reading tasks in the form of objectives lists for students with reading difficulties. The Hants Special Needs group addressed this problem by presenting their skills lists in cartoon form and found the students enjoyed and appreciated this style of recording.

We now return to the purpose of this style of recording for those students with learning difficulties. In their case, we are interested in gleaning more information about the nature of their needs for both teacher and student, so that learning can be organised which more effectively takes into account specific learning difficulties. On this basis any profiling system should start by looking at what students *are* able to do and proceeding from there. The problem with the teacher-created, whole-class lists is that they are in danger of setting unachievable goals and hence promoting feelings of inadequacy. For example, a profile list for a first year course must of necessity include objectives for 'the high-fliers' as well as those with learning difficulties. In the long term, these objectives are appropriate for *all* students, but students will vary in the speed at which they achieve them. Our plea therefore is that individuals are set short-term, achievable goals while being aware of how these represent progression towards more long-term objectives.

The preparation of individual objectives lists in negotiation with the students is one way of ensuring we know where they are starting from and what represents a realistic target. An alternative tack invites students to present lists of statements of the kind 'What I have achieved this week/term' and 'What I have had difficulty with'. This clearly is a more open-ended assessment method, not limited by teacher goals but by the students themselves.

Another open-ended means of student self-evaluation (as well as curriculum evaluation) arises out of the work of the Wiltshire *Learning Logs* group. They encourage youngsters to express themselves in their own journals to help the learning process (**2.3**). These journals are personal records in which the students are free to write as and when they wish and to share with the teacher when they feel it is important. Therefore they can talk to the teacher through their journal. As well as being a mechanism to encourage students to sort out their own thoughts, it also provides a means by which they can record impressions of their own progress, raise their worries and difficulties with the teacher and request answers to questions which they did not feel confident enough to pose in class. This personal and expressive writing can thus provide us with a wealth of information about individual young people but depends critically on our willingness to treat such discourse confidentially. Not only does this approach provide information

for the teacher, but it can also be a mechanism which encourages students to reflect on their own progress and consider their own future needs.

> *Probably why I get half of it wrong is because I don't read the questions and instructions properly because I'm not interested. The diagrams are clear but for some of the instructions, you have to read them about five times.*
>
> second year pupil (2.3)

An immediate problem which springs to mind in suggesting this approach for those with learning difficulties is that it asks them to communicate in written form – a well-recognised sticking point. But the fact that the work is not in any sense graded means that students can express themselves without the threat of being judged on either writing or science ability. However, if writing is an acutely limited factor, it may be worth considering other means of communication. The use of small group discussion, talking onto an audio tape or producing cartoons come to mind as possible variations to this strategy.

The benefits of working alongside special needs staff cannot be underestimated in this context. Such a teacher can work closely with individual students in order to gain a better understanding of their specific difficulties.

In this section we have tried to reinforce the view that effective practice requires the identification of individual pupil needs. We have argued for using as wide a range of sources of information about such needs as is practicable and offered some limited strategies for collecting, collating and using such information. Constraints of time and the practicalities of day to day school life cannot be ignored, but even within such constraints, we are convinced that most science teachers and departments would gain from a review of their procedures and practices in knowing about the individual young people in their charge.

Box 8 *A summary*

SECTION THREE

A case study

Much of this publication is directed at teachers in mainstream schools and lays out some basic principles to be considered when planning science for those with learning difficulties. However, 'principles' do not give us any idea of what is going on in the classroom. Therefore the following case study is provided in order both to give a flavour of the quality of experience which science can generate for young people with learning difficulties, as well as to focus on the practicalities which are entailed.

The case study is about collaboration between science teachers in a mainstream school and teachers from special schools in Berkshire. With moves towards integrating children with special educational needs into mainstream schools, it is vital that we are able to draw upon each other's expertise. This case study is a story, honestly told, of the hopes and fears of one science teacher faced with students' learning difficulties with which he was unfamiliar. It provides pointers to some of the practical aspects of collaboration and describes the benefits which accrue for all those involved. Most particularly, it may challenge some deeply held beliefs about young people's capabilities.

Special school/mainstream school collaboration

Dave Berrington, Little Heath School, Berkshire

History

Like all good stories, this liaison started purely by accident. Martin Hall was a teacher whom I had met from The Avenue Special School in Reading who taught rather frightening sounding kids in wheelchairs. They obviously had no science provision and it seemed a bit churlish not to offer some help such as a loan of equipment. Before I realised, I had offered to take his group for a session in our labs – just on a one-off basis – during one of my precious free periods!

Martin turned up on the appointed day with ten children in their specially adapted ambulance. There was a mixture of ages, abilities and disabilities, but the one common factor was the sense of excitement and an overriding enthusiasm. We had a smashing lesson. I can't remember what we actually did, apart from gaze round the lab in awe and wonder, but I do know that it was a very simple problem-solving exercise just to keep them going. I finished the lesson just before the bell and we all went over for a school lunch (the kitchen staff were expecting us).

As I watched them in the dining hall I was worried by the total lack of interaction between the two sets of alien cultures, but when I went outside after lunch I found a group of our third formers watching with considerable respect as two of the physically handicapped boys did wheelies in their wheelchairs – until Martin came out and caught them at it.

The morning had gone so well that I ended up inviting them on a once a fortnight basis, and that is how it all started. My headteacher was obviously fairly enthusiastic about it – the Warnock Report had only recently come out – and so when I went to him at the end of the year and suggested that this be formally timetabled in for next year instead of during my free periods he actually agreed!

Somehow, that was just the beginning. Now that I was timetabled for a double period a week we decided to take on another group rather than double the time allocation of the pupils already coming. So commenced my introduction to teaching 'pupils with moderate learning difficulties' – the sort of kids that I had previously called ESN.

The following summer term we had a visit from Ann Wrighte, the deputy head of the nearby Brookfield Special School, to see what we were doing. She was delighted to see this sort of liaison taking place, enthused about the work we were doing and asked when it would be convenient to bring a group from her school! We managed to fit her in for a trial period in place of a departed fifth form group, and on the strength of that my headteacher was willing to re-timetable me yet again.

As a result of this, several schools started meeting as an SSCR group and at least two other secondary schools and one other special school have been taking part in a similar arrangement. At my own school several of the science staff are enthusiastic about the link and it is very pleasing to see the way that they have taken over the commitment.

The tale would not be complete without a Fairy Godmother, so we even have one of those. The county said they would put in some SSCR funding and the school's staffing allocation has been increased by 0.1 to pay for it all.

Approach

Perhaps the most important thing about this project is that we have *not* seen it as a way of

introducing a science curriculum into special schools. The participating schools all saw its value as much more to do with the links between staff and confidence building in *both* directions, and also in giving a much broader beneficial experience to the pupils than just that of a formal science curriculum. As we were working on a fortnightly basis I could not bank on any retention of memory, so we decided to approach the work from the standpoint of a set of experiences which would make the students think. That viewpoint had a very valuable effect on me; it meant that all my lessons had to be based on activities justified as being worthwhile in the short term – I was committing myself to a set of process-based, problem-solving activities. When I looked at our lower school science syllabus for ideas that I could use I realised that there were a lot of lessons that we were teaching that didn't fit that mould!

A second decision that was taken, perhaps almost as accidentally, was to do with the layout of the lab. When that first group came in their wheelchairs, they couldn't get to the blackboard so we all sat at the back of the lab in an informal circle. This I later realised suited the much more informal approach that they were used to in their own much smaller schools, and since then I have hardly used the board at all.

The third decision, which was taken much more consciously, was to avoid writing wherever possible. It was their minds I was after – their thought processes – and I didn't want them clouded by the frustration of not being able to read or write during the lesson. We arranged a much more suitable system – their own class teacher did follow up work back at their own school to capitalise on the enthusiasm engendered, and that included the writing component.

Content

We covered anything and everything that I could think of. Once they had got used to things, there were sufficient ideas coming from the students to keep me going, so I stopped worrying too much about long-term plans and allowed each lesson to dictate what we did in the next – within limits. The most important thing about the list we covered is that it is so refreshingly normal – all the absolutely standard things worked just as well with them as with the mainstream classes, so long as there was a problem-solving component.

What did I get out of it?

The most important thing I got from this liaison is the knowledge that 'handicapped' children are individuals just like anyone else, that they respond to the same sorts of things that my 'normal' children do, and that it is possible to forget their handicap and just get on with the job of running a lesson. In more general terms it has removed a 'fear of the unknown' for several of the staff in our school – a worry that I have heard expressed in other schools as well.

Apart from that, my initial reaction to the question was 'not much', apart from a general sense of fun, of virtuous glow and the occasional mention in the school newsletter. However, I now realise that there has been another effect as well. The knowledge that this group of children is coming to my school each week just for this lesson has forced me to ask myself what it is that I am really trying to achieve in each lesson. This has then made me look at our lower school science curriculum and identify a lot of 'padding' which is not science and certainly is not making our mainstream pupils think for themselves. When I have finished writing this I must revise our syllabuses thoroughly.

Perhaps the virtuous glow was more important than I at first realised. Both Ann and Martin stayed with their pupils during the lessons in order to help. From both people I got the sense that I was doing something for their pupils that they could not do – quite intoxicating stuff! At the same time I gained from their expertise which helped my teaching of children with mild learning difficulties in my ordinary lessons.

What did our comprehensive pupils get from it?

- A sense of acceptance of people with physical handicap – timetabling the physically handicapped group to share lunch with the rest of the school helped with this.

- A genuine feeling of respect for the capabilities of people who were so obviously disadvantaged, if only to the extent of doing wheelchair wheelies in the school playground.

- A sense of their own value in society. We encouraged our pupils to act as hosts to the physically handicapped pupils for the last quarter of the lunch hour. One memorably unruly and troublesome fourth year girl found in that something which she enjoyed, was good at and which attracted praise from the staff. She blossomed under her new-found responsibility, and while I cannot claim a complete change in her personality, there was a definite improvement in her ability to interact with her peers and with staff.

What did the special need pupils get out of it?

- A sense of worth. They were going to the big school to do science. This was an experience they could have in common with their friends who went to the big school, and it made them special in the eyes of their friends back at their own school. It has reduced the social stigma of going to a special school for those kids.
- Scientific stimulus and experience. These children had not been exposed to the idea of scientific problem solving chiefly because their own staff did not feel confident in that area. Both Ann and Martin soon started doing follow up work in their own schools once they had been a few times and begun to absorb the notion of conducting investigations and carrying out 'fair tests'. The main hangup appeared to be the image of science as a subject that could not be done without the expensive formal apparatus.
- A vehicle to be imaginative and creative, as in devising the best way to set up a cooling race for beakers of hot water.
- Self-development. It was interesting to watch one child showing the other, who had been absent, how to use a Bunsen burner. He was proud to be able to show his skills.
- The confidence to express an idea without fear of ridicule; a willingness to question; cooperation skills. Motivation – even the poorly motivated 15 year old moderate learning difficulty children felt that they were going somewhere special, forgot about themselves and joined in.

What did the special school get out of it?

Ann has taken the message back to her school and this has led to a reassessment of their curriculum and approach, to an increased emphasis on skills and problem-solving approaches, even to the appointment of a specialist science teacher. Martin went back and enthused to the point where several other staff wanted to bring their classes to our school. These came on the free week of the fortnight and the school has been slowly building up a nucleus of staff who are willing to use scientific approaches as part of their normal classwork.

There has been a noticeable increase in the levels of expectation of what the children can do by some of the special school staff. This was particularly noticeable when the children's usual teacher could not come and they were accompanied by another who was unfamiliar with the level of progress that those pupils had managed to achieve.

What sorts of problems arise?

Probably the main problem is lack of continuity. The physically handicapped children appear to be much more susceptible to illnesses, or are kept at home as a safety precaution, so there is rarely a full group. Both schools change their sets at odd times so that the composition of the group coming to me might well change more than once in the school year. I try to keep a list of what I have already done and try to make sure that the work remains stimulating for them without repeating or assuming a background that most of the group does not have. This has several times been turned to advantage when I have been able to use some members of the set who have previously come across a topic or technique to help me explain it to the rest. It not only does wonders for their morale but also forces them to sort out a lot of things in their own heads.

The physically handicapped have obvious problems which for the most part I have ignored, though I have been careful not to push things too far. There was always a welfare assistant who came as well as the class teacher, and sometimes we even got the ambulance driver to join in if he wasn't needed to ferry anyone else in the interim. There is no reason why handicapped pupils shouldn't get their own apparatus out of the cupboards, even if it does create a bit of congestion with four wheelchairs round the Bunsen cupboard. We have since developed a one-way flow system for such contingencies. My main battle has been with Martin to stop him helping them too soon instead of giving them more time to fight it out for themselves. We all found that it was terribly easy to fall into that trap. One of the students, Selma, surprised both of us when we started playing with pulleys. She was determined to set up a pulley system for herself, with hands that never kept still because of her cerebral palsy. She fought both of us back to a respectful distance; she fought the apparatus on the bench; she fought the bits on the floor. Eventually she stood back with a completely assembled pulley system and an expression of supreme satisfaction and achievement on her face.

We have not made any special apparatus because we have been concentrating so much on devising our own answers to problems. This means that there has been little need for formal experimentation, or specialist apparatus and techniques. The main changes have been in working practice – it is easier for a wheelchair-bound child to perform an experiment on a low table or even to use the stools as tables. The only physical modification I think we needed to do was to put longer tubing on some of the Bunsens.

The main problem with the pupils with learning difficulties was their problem with reading – both words and instruments – and sequencing. We

avoided the former by avoiding worksheets in most cases, or if we did use them we made the worksheet up of a series of slips of paper each containing one instruction only. When using instruments such as thermometers we just had to allow a lot of time and noting changing temperatures had to be done more on the lines of 'tell me when it gets to the 40 mark' rather than 'tell me the reading at this instant in time'. The APU material which I read later more than confirms this difficulty.

Typical lessons

11 March 1985. Ann arrived with the new Brookfield group just as the lessons changed over. Looking at the faces I saw one that I recognised from their last set of visits of six months previously. Apparently I should have recognised four of them. We sat in a circle in the centre of the lab and I got them to tell me their names. Then I tried to remember who they were – it was, as usual, hopeless.

This introductory lesson was to be on air – I had ready syringes, parachute-making kits and candles to burn in different sized jars. We all cottoned on to what was in the beaker quite easily – 'air sir!' – but they had much trouble deciding if you could feel air. We flapped our hands in it, but then forgot that we had just felt it. Someone mentioned wind but we had enormous problems linking wind with moving air. Then to the 50 cm^3 syringes. That was fun – 'You can't push it right down!' – But I could not get them to observe the way the plunger moved back up when they let go. Eventually they saw it, but not as a property of air, so back to much discussion of what air must be like if it pushed the plunger back. I had much difficulty getting 'springy' or 'rubber', so in the end I dashed out for the elastics kit and came back with a tray full of bedsprings and foam rubber and we all squeezed those before going back to the syringes.

In every case, I had to gently collect all the apparatus back from the children before we could concentrate on talking. We broke the lesson at regular intervals to recap: What can you go home and tell your granny that you did in the lesson? We did not manage to get as far as the parachutes, so Ann agreed to do them back at Brookfield.

On the way out, one child went to look along the wall to where we had seen the heat haze last summer. I was astonished – something had gone in! (Looking back at this a few lessons later, I wonder if their inability to think and to tie things together was a lack of confidence and the lack of familiarity with me after the gap. They were much better at it in the following lessons.)

25 March 1985. They all came today with parachutes and paper aeroplanes which we dutifully threw out of the window. Someone had suggested that a parachute might go upwards in hot air so we tried it over a Bunsen – after a sidetrack of looking at the Bunsen flame and all of us feeling the burner itself to see if it wasn't too hot to touch. The parachute didn't rise, though the hairs on the back of my neck did. Thinking of hairs, one of their first questions when they came into the lab was: Why is your beard a different colour from the hair on your head? So we talked about pubic hair and armpits as well. They are more willing to ask unrelated questions than my normal classes.

We then tried burning candles in different sized jars. At first they did not notice the size difference and I didn't insist that they all start at the same time – I just allowed them to confirm that the candles went out. Then someone said that their candle went out faster, so we had a candle burning race and discovered the effect of jar size. No clue why as yet – more next week!

Link hints

If you are thinking of setting up some form of link between a special school and a mainstream secondary school, the following suggestions may be useful.

- Find an enthusiast! Ann got her link because she wanted it, enthused about it, and had the nerve to ask me to take it on!
- Find out who has the power over the timetable when setting the link up in the first place.
- Decide what you want to achieve as well as the science lesson. One school takes a party of special school children for science and then they go on to a double period in the school's sports hall. We take ours over to school lunch.
- Think of who else in the school may want to be involved. We have taken up offers from other teachers, from sixth formers who wanted to help with the lessons as part of their community service work, from fourth formers who acted as company for those special school children who ate sandwiches instead of eating a school lunch.
- Make sure that the teachers from both schools are in the room with the children; you can both help each other. I found comments about language use, sequencing of instructions, number work and ways of reading instruments to be very useful. I think that I have been useful in showing the basic approaches which can be taken back to the other school and also in suggesting follow up work.
- Give feedback and encouragement to the other teacher. You are both exploring the unknown and will need to know where you did it well.
- Take a global view. Remember that they are getting a much broader experience than just a science lesson from their visit.
- Beware of doing a formal science lesson – it didn't work!
- Have fun, it's contagious!

SECTION FOUR

By responding to their needs we make science accessible

Introduction

Having had a look at some examples of curriculum development in action, we now turn to a consideration of some of the general principles which may inform future planning of the science curriculum for those with mild and moderate learning difficulties. These principles might be applied to the science education of all students and are fundamental to the planning of science in the curriculum. By starting with the needs of those with learning difficulties and building on this firm foundation to meet the needs of others, we believe science education will improve for the benefit of *all*.

We take as our framework some of the other SSCR resource documents and the different aspects of entitlement to science education which they detail. It is our intention to consider how we might best structure science education to give access to this entitlement for those with learning difficulties. Wherever possible, we try to exemplify our proposals by drawing on the work of SSCR groups. These aspects are considered under five headings:

- Content
- Contexts
- Teaching and learning approaches
- Assessment
- Organisation.

Content

The case for a process approach to science education has been argued for *all* young people, both in our own publications as well as those from the DES, APU, HMI, etc. The writers of the Warwick Science Process Scheme point out the strengths of such an approach for students with special needs:

> *If children with special educational needs are taught to observe, classify, predict and hypothesise in an interesting and exciting way, then science education is surely equipping them for life in the real world far more effectively than teaching them about the structure of a flower or the rate of acceleration of a trolley on a slope. That is not to say that the ability to classify flowers or plants or to predict that the higher you raise the slope, the faster the trolley will move is not an effective way of teaching the processes of science.*

The message here is for a change of emphasis. The skills and processes should be a prime focus for our teaching and not just developed along the way. What better vehicle for the development of skills than the practical approaches to science? However, for such an approach the choice of content is of great importance. A look at the module titles of some SSCR groups working in this area give us some idea of the criteria used for selecting content. There are titles such as:

- Healthy bodies
- Food preservation
- Flight
- Electricity at home
- Fibres and fabrics.

Some of these titles are chosen because of their intrinsic interest, others perhaps through consideration of the future prospects of young people. Such criteria are acceptable provided that consideration is given to the overall richness of the student's curriculum. Two important aspects relate to:

- the breadth of coverage;
- the balance of skills, processes and attitudes.

The breadth of coverage

As far as entitlement goes, we might ask whether the content gives the breadth of science ideas which are detailed in the SSCR Curriculum Guide **Better Science: Choosing content**. The CHASSIS group (**4.1**) developed their own key concept list and used this to analyse several of the schemes currently in vogue. Their analysis of the 'concept cover' from some of the *Open Science* (**1.3**) units is reproduced in Box 9. The group use asterisks to identify individual units where a concept is featured.

The criterion of 'relevance' is important when selecting content, but if we are not careful we are in danger of emphasising only those topics related to the perceived future prospects of young people. While home and vocational topics can be interesting and motivating, it is important that they are not used exclusively at the expense of other topics which are aimed at broadening students' horizons, developing their imagination and encouraging them to empathise with others.

Perhaps access to some topics is not so obvious

Concepts	Units in 'Open Science'												
	EH	FM	FI	GY	KG	LS	MM	PO	SE	SH	SC	SS	ST
A Materials													
1 Acidity								•	•		•		
2 Building blocks											•		•
3 Change of state			•										
4 Expansion and compression		•	•				•						•
5 Linear dimension, area, volume and time	•	•	•	•						•	•	•	•
6 Oxidation: combustion, respiration and corrosion			•		•		•						
7 Pressure		•					•			•			
8 Pure substances and separation of mixtures			•		•			•					
9 Weight and gravity			•							•		•	•
B Energy													
1 Conversion of energy forms	•	•	•		•		•	•			•		
2 Electricity	•	•			•		•				•		
3 Electronics											•		
4 Force, work, power and friction	•	•			•		•			•		•	•
5 Forms of energy	•	•	•				•			•	•		
6 Foods and fuels	•		•				•	•	•				
7 Heat transfer	•		•		•		•			•			•
8 Machines as energy converters	•	•					•				•	•	•
9 Magnetism							•						
10 Photosynthesis													
11 Temperature	•		•		•				•	•			
C Environment													
1 Adaptation													
2 Body transport								•					
3 Dietary balance													
4 Growth				•					•				
5 Inheritance													
6 Misuse of environment			•		•	•		•					
7 Natural environment: the Earth			•			•		•	•				
8 Senses and perception	•		•					•		•			•
9 Sets, classification and keys				•		•							
10 Use of the environment			•	•		•		•		•			•

EH	Electricity in the Home	FM	Find out about Machines
FI	Fire	GY	Grow Your Own
KG	Keeping Going	LS	Life Spotting
MM	Machines on the Move	PO	Pollution
SE	Safe Eating	SH	Science at Home
SC	Snaps and Circuits	SS	Starting and Stopping
ST	Structures		

Box 9 'Open Science' *units* **(1.3)**

as it is with those topics more likely to be viewed as 'relevant' and clearly related to their everyday lives. However, consider the approach adopted by a Somerset teacher when developing work on 'Astronomy' which demonstrates how teachers might start with young people's own experiences and encourage them to test out their own ideas.

One of the introductory activities is to get students to investigate their own ideas about day and night. The activity is introduced by listing ideas from some other students:

> *We get day and night when the moon passes in front of the sun*: John
>
> *Because the Earth circles around the sun every day*: Sarah
>
> *The sun shines over the North pole in the day and over the South pole at night*: Jim

From using models to examine their own ideas, students are encouraged to make observations using telescopes and to record their findings. Other work on 'the stars' begins with a critical look at horoscopes, getting them to compare predictions from different newspapers and magazines and thus practising pattern finding. It seems that even a subject which has often been dismissed as too mathematical and without practical appeal for students with learning difficulties can be made accessible if we introduce it so it builds from the students' own experiences and ideas.

Work which begins with personal experience can also be developed in order to encourage an understanding of other cultures. The work of the Leicestershire *Science Education in a Multicultural Society* group is a good demonstration of this. Among their suggestions **(4.2)** are investigations into the methods of metal extraction, charcoal production and food preservation which are practised by people from different cultures.

The balance of skills, processes and attitudes

Referring back to the work of the Avon *Half our Children* group **(1.5)**, it seems that current fourth

and fifth year courses often do not provide such a balance for skill development. (We suggest that this is also the case for many courses for 11–14 year olds.) Teachers who used the evaluation tool found that opportunities to develop certain skills did not feature at all in their courses. Therefore we might propose that another criterion to be used for content selection is whether a topic provides opportunities to develop skills in a systematic way.

To summarise, we phrase our first statement of entitlement:

> **Entitlement to content in science means ensuring overall breadth while at the same time enabling skills to be practised and built upon.**

However, these are not sufficient conditions for access for those with learning difficulties. If this was true, then science education could in theory be reduced to a series of drilling exercises removed from any context. Current theories of learning strongly challenge such notions and suggest that the contexts in which science is presented are very influential on the outcomes of learning. Thus access to content cannot be divorced from a consideration of the appropriate contexts in which content is presented.

Contexts

Entitlement in this sense means that young people must be able to relate their school science to their own lives. As was pointed out in Section 1, many of the existing schemes have made an attempt to do this in that they are rooted in the applications of science. Developments which move on from this 'applications' approach start with the student's own environment and experiences. In Northern Ireland (**4.3**), materials have been produced which provide information about the local geology and which encourage students to carry out investigations into their own environment.

Another Northern Ireland group linked their work on joints and muscles in the unit 'My healthy body' to special weight-training sessions at the local recreation centre to good effect, as the teacher describes:

> *This was the first time pupils had ever contemplated entering such a place, realised the reasonableness of the cost and the interest within. Here was something they could do, and in many cases do it much better than their more able peers*
> (personal communication)

Many groups have pointed out the importance of having a tangible outcome from practical work. Activities such as making models to fulfil a brief, for example:

- a wind-powered vehicle;
- a bridge;
- a warning device;

are featured in the problem-solving suggestions of many groups (see for example (**4.4–4.6**) and are claimed to be great motivators and confidence boosters.

Teaching science in the context of farming can result in 'edible' outcomes, as can science through cooking. The practical activity is seen to have purpose while at the same time students are practising the processes of science and gaining a deeper understanding of the concepts. At this point, readers may ask whether they need to teach science to those with learning difficulties if they can learn it through subjects in other areas of the curriculum. We would point out that we are advocating that sometimes these subjects ought to be used as vehicles for teaching science processes and concepts. Such a scientific approach requires more than merely following the instructions on a recipe or on a packet of seeds. It is an approach which encourages students to ask questions, to test their own ideas and to evaluate the results.

Often the tangible outcome of a science lesson is some written contribution. For many young people, this presents particular problems because of poor literary skills. Given the contribution that science can make to the development of these skills, it is worth considering how students might be encouraged to engage in an activity at which many feel inadequate. Writing answers in a notebook for the teacher may not be seen by many young people to be particularly purposeful. However, if a context for writing is provided, then there is a reason for struggling with the language. This might mean, for example, preparing information posters or leaflets, writing a children's story or producing a script for a radio programme. Our second statement of entitlement is therefore:

> **Science education should be set in meaningful contexts for students. This means providing maximum opportunity to relate science to their own lives whilst at the same time encouraging them to extend their life experiences.**

Teaching and learning approaches

An emphasis on the development of skills and processes means consideration of whether the approaches to teaching and learning are designed to achieve these objectives. For example a group from Cleveland produced the checklists shown in Box 10 to help them identify the strengths and weaknesses of some teaching and learning approaches in the development of social skills.

Personal and social skills

The development of social and personal skills plays a vital role in the teaching of science.

It is essential that science teachers develop the best conditions for personal and social skills to evolve. The following list indicates some possible skills which can be developed through science. (It is recognised that personal and social skills are necessary for the pupil to benefit from science teaching, but the emphasis in this section is the development in the pupil of the skills in their own right.)

Skills

1 Seeking help
2 Offering help
3 Independence and self-reliance
4 Self-motivation
5 Self-confidence and self-esteem
6 Perseverence
7 Listening to others
8 Leading
9 Cooperating with others
10 Working to a common aim
11 Respecting/tolerating the views, needs, rights of others
12 Influencing the views of others
13 Evaluating self and others
14 Flexibility

Strategies

At present in science teaching a wide variety of strategies are/can be employed, more so than in any other area of the curriculum. Some are listed below with an indication of personal and social skills which may be developed by them.

Teaching strategies	Skills
(a) Lecturing	
(b) Demonstration — teacher	2 9
(c) Demonstration — pupil-run	2 5 9 8 11
(d) Discussion — teacher-guided	5 7 9 10 11 12 14
(e) Discussion — pupil-guided	3 9 8 9 10 11 12 13 14
(f) 'Recipe' practical	1 2 3
(g) Individual practical	1 3 4 5 6 13
(h) Group practical	1 2 3 6 7 8 9 10 11 12 13
(i) Project work	1 3 4 13
(j) Problem solving	1 2 3 4
(k) Copying and dictation	
(l) Independent learning scheme	1 3 4 5 14
(m) Homework	4 6 13

Box 10 *A social skills checklist*

This gives rise to a third statement of entitlement:

Teaching approaches should be designed to match the desired learning outcomes.

For students with learning difficulties, achieving a particular learning outcome may require a great deal of practice; skills or key concepts may need to be revisited many times. Without careful planning, students could find themselves repeatedly failing at the same task. For example, many of the topics in published fourth and fifth year courses involve activities which many students may have met in lower school. Some of the skills which are tested and then recorded on some of the new 'science achievement certificates' are ones which students will have been practising since primary school. Some of the levels of achievement from the CHASSIS (**4.1**) work serve to demonstrate this:

Classifying:
Level 3 Classify objects from written, spoken or visual information
Level 2 Classify objects from spoken or visual information
Level 1 Classify objects from visual information
Level 0 Skill not mastered
Measurement skills:
Level 3 Use scales, make estimates and supply correct units
Level 2 Use scales and supply correct units
Level 1 Use linear and digital scales
Level 0 Skill not mastered

Our fourth statement of entitlement is therefore about variety:

Access to the skills and content of science means providing many varied learning experiences to enable achievement of a particular objective rather than the dreariness of constant repetition.

For example, measurement skills associated with a topic on electricity could be developed by:

- Specific skill training: by following instructions on how to use an ammeter.
- Measuring in the normal course of carrying out investigations: through measuring the amount of current required to 'blow' fuse wire of different thicknesses.
- Role play: with an electrician teaching a new apprentice how to use equipment.
- Problem-solving: by designing a way of measuring the brightness of a bulb.

Another Curriculum Guide in this compendium, **Better Science: Approaches to teaching and learning**, is devoted to a wide variety of approaches which are at our disposal. Choosing the particular approach which best suits individual students is the important consideration in the context of this document. This means ensuring that learning difficulties do not 'get in the way' of engaging in science. For example, poor written skills should not prevent students from recording their findings. This might mean providing alternative ways of presentation through use of posters, cartoons, verbal reporting, etc. That is not to say that science teachers should accept poor written skills and not aim for improvements, but as we pointed out above in *Contexts*, writing and producing display material for different audiences is a great motivator and motivation is the key to success.

Specific language development activities ought also to be part of our 'toolkit'. The Gloucestershire language group include suggestions for possible activities which encourage 'active' reading (**4.7**). Some practical examples of 'Directed Activities Related to Text' (DARTs activities) are also described in the Curriculum Guide **Better Science: Working for a multicultural society**.

Particular problems associated with practical work

Many teachers have pointed out the difficulties of providing opportunities to do any kind of practical work with youngsters with behavioural difficulties. Safety in the laboratory is always a concern, but many would argue that these particular youngsters constitute a major hazard. The prescriptive nature of practical work which is a feature of much current practice offers teachers considerable control over what goes on in the laboratory. However, if we are to introduce more opportunities for open-ended investigations, this control may not be so easy. How can we enable access to open-ended problem-solving for those with behavioural problems while ensuring laboratory safety?

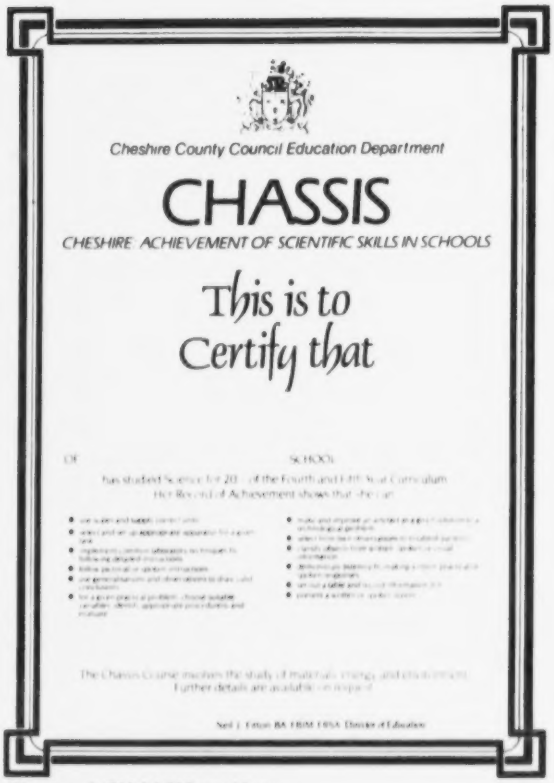
A number of SSCR groups have developed and tried out problem-solving activities with such students and have found these worries to be unfounded. They argue that the greater motivation created by these activities in itself helps to overcome some of the behavioural problems. Many of these activities were technologically oriented in that:

> *Pupils were presented with a challenge of a kind which entailed them devising and making some form of device in order to meet it*
>
> **(4.6)**

Assessment

We have already focused on aspects of diagnostic assessment in Section 2. This type of formative assessment is designed to inform teacher and student and thus foster the learning process. However, as the Essex survey demonstrated, informing outsiders is, quite rightly, a main priority of many schools. Often this information is simply achievement in examination subjects and for many of the young people we are talking about, this could mean the simple message 'failed'. Dissatisfied with disseminating information in this way, many schools have developed assessment procedures which better meet the needs of those with learning difficulties. Records of achievement in science have been developed by a number of authorities. The CHASSIS group use criteria for proficiency in different skills to produce a certificate like that shown in Fig. 1.

Practical assessment is thus a very important part of the information collection required to compile such a record of achievement. The difficulties which some youngsters experience with the written word means that they are often unfairly judged with regard to their understanding of science. Assessment of their ability to recall information and apply scientific ideas is usually carried out by means of written tests. In an effort to take account of this and thereby give access to examination achievement, a Hampshire group developed a 20% oral componant in their Mode 3 GCSE submission based on *Science at Work* **(4.8)**. The objectives of the course which the group felt were most suited to oral assessment were:


Cheshire County Council Education Department

CHASSIS

CHESHIRE ACHIEVEMENT OF SCIENTIFIC SKILLS IN SCHOOLS

This is to Certify that

Fig. 1 A CHASSIS certificate

1 To communicate scientific concepts
2 To develop some basic concepts in science
3 To develop an awareness of the contribution of science to the economic and social life of the community.

Oral tests were developed which aimed to assess these objectives. Students were scored using criteria developed by the group and moderation of the assessments was made possible by examining videos of some of the candidates doing the orals.

With regard to assessment, our entitlement statement is as follows:

> **Students should be provided with assessment strategies which allow them to demonstrate their capabilities and have them recorded for other audiences. At the same time, they should have access to diagnostic assessments to help them to identify areas of difficulty and follow-on activities which help them to improve weak skills.**

29 BEST COPY AVAILABLE

Organisation

Up to this point, this section has been concerned with the nature of the curriculum, that is, what the science curriculum for students with learning difficulties might look like. Having sound educational ideas and aspirations is all very well, but do the organisational frameworks exist within the school in order to deliver this curriculum? In this section we examine four aspects of organisation which, although pertinent to all young people, we feel merit particular mention in the case of those with learning difficulties. They are:

1 Curriculum organisation
2 Student organisation and grouping
3 Organisation of learning in the classroom/ laboratory
4 Staffing allocation.

Before considering possible models of organisation, we take this opportunity to summarise some of the basic principles with which we have been working so far. These may then serve as criteria on which to base decisions about the kind of organisation which is appropriate. The principles in Box 11 are adapted from work carried out in Leicestershire.

Ensuring access to science means:

1 Studying young people as individuals and discovering their preferences and interests.
2 Making careful diagnoses of their learning difficulties.
3 Breaking the necessary learning down into small steps. This means setting them objectives which are both achievable and worthwhile in their eyes.
4 Enabling young people to see their own progress and reinforce their learning.
5 Providing opportunities for young people to contribute to class, year group or whole-school science activities.
6 Providing opportunities for young people to become independent learners.
7 Keeping careful records, reviewing progress regularly and modifying programmes of work where necessary.
8 Providing as many opportunities as possible for improving self-esteem.

Box 11 *Basic principles*

We acknowledge the external constraints which may prevent us creating the organisation which is best suited to meeting these principles; nevertheless they are goals worth aiming at. We now examine the implications of these principles in terms of the four aspects of organisation already referred to.

Curriculum organisation

This is the subject of another SSCR resource and does not require detailed examination here. However, we would point out that if 'getting to know and understand individual student difficulties' is to be one of our guiding principles, it behoves us to organise the curriculum so that it enables us to do just that. If organisation of the curriculum results in an individual student meeting a particular science teacher only once a week for a year, as may be the case in year three when often science is split into physics, chemistry and biology, this is not necessarily an effective way of getting to know individuals. The same criticism could be levelled at modular curricula which might entail meeting different teachers for each module. We are not in any way dismissing such approaches; on the contrary, a school might opt for such an organisation on very sound practical and educational grounds. However, we would hope that a look at the criteria would cause a school to consider ways of ensuring that students' needs are catered for. For example, some schools with modular science and technology courses assign each individual student a science tutor for the duration of the course.

Student organisation and grouping

The debate about the merits and demerits of mixed ability teaching versus separate provision is long standing and we do not propose to recommend any particular form of group. What is important is for a department to organise its teachers and students in the way best suited to achieving the goals listed above. Perhaps one of the most important considerations is how to gain maximum benefit from staff expertise. Special needs staff have much to offer in terms of identifying difficulties and planning individual learning programmes, although they may be unfamiliar with much of science curriculum we wish to offer.

A situation which enables science teachers to work alongside special needs teachers in the classroom for at least some of the time allocated to science is a promising possibility. This may not be feasible to organise for say two students in a mixed ability group and is more likely if there is separate provision. However, grouping together youngsters with difficulties brings its own problems, not least of which is the self-image that the youngsters may have of being part of a 'sink' group and therefore not engaged in science activites of equal value to those undertaken by their peers in other groups.

Taking a wider view of organisation, it may be that more flexibility can be introduced by operating a block timetabling system. In this case, it is theoretically possible to maintain 'separate

provision' at key times while enabling youngsters to work with the rest of their peers in mixed ability groups at other times. In this way special needs teachers are seen as integral parts of the teaching team rather than additions to help with difficulties. Close collaboration between all staff will be required to coordinate work and all students stand to benefit in that curriculum planning starts with the access requirements of those with learning difficulties and works upwards. (See (4.9) for suggestions for a more analytical approach to organisation.)

Organisation of learning in the classroom/laboratory

The emphasis on examining and responding to individual needs demands that we consider closely the way learning is organised in the classroom. Given the variation of needs and the desire to set achievable goals for each individual, it is difficult to see how our aims can be achieved through continuous 'whole class' teaching where all students in a group follow the same programme of work. Many teachers have moved towards introducing a more independent-learning approach where individuals or small groups work towards particular goals which have been negotiated with the teacher. Others work using a model of core-plus-extension, where extension in this case might be more demanding work for those who get through the core with relative ease, while for those with learning difficulties it will be varied activities which help them to practise the ideas and skills within the core.

Opportunities for teacher presentation, class discussion and demonstrations are still utilized, but the emphasis of such approaches is on students becoming more independent learners. This means that the teacher is cast in a different role and considerable attention must be given to classroom management of resources, student groupings and record-keeping of each individual's progress.

Staff allocation

There can be no doubt that the deployment and utilisation of staff is the critical issue for all the aspects described above. Separate subject teaching locates teachers in particular areas of study; non-streamed groups, for example, require particular teaching skills and resources, while varied approaches in classroom/laboratory working are similarly demanding of individual teacher enterprise and ingenuity. What then is the message with regard to delivering appropriate learning support to those students who require it?

Our message is simple and requires that the available resources of both the department and the whole school are deployed to best effect. The devising of well judged and sequenced curriculum packages is best served by a working team of teachers. Record-keeping and the assessment and valuing of young people's work needs a similar corporate and agreed approach. Particular talents, skills and expertise are to be found both within and without the science department. For example it may be that Bill from the classics department is a skilled photographer, Sally from the learning support unit knows about readability, while teachers involved in active tutorial work bring other perspectives and so on.

This section has set out some broad principles with regard to providing access to an appropriate science education for those with learning difficulties.

We have recommended:

Content
- An emphasis on the development of skills and processes of science.
- Content which is not constrained by the perceived future needs of the young people.

Contexts
- Appropriate contexts for science education which are meaningful for young people.
- Practical work which has tangible outcomes.

Teaching and learning approaches
- A better match between teaching and learning approaches and desired learning outcomes.
- Provision of varied learning activities to enable students to practise and reinforce key skills and ideas.

Assessment
- Strategies which offer alternatives to written assessment.
- Methods of recording achievement which emphasise what young people can do rather than what they cannot do.

Organisation
- Classroom organisation which gives students more responsibility for their own learning.
- A 'team' approach which best utilises the human resources of the school.
- Close collaboration between science teachers and teachers with responsibility for students with special educational needs.

Box 12 A summary

Further reading

General

Brennan, W.K. *Curriculum for Special Needs*, Open University Press, 1985

Clunies-Ross, L. and Wimhurst, S. *The Right Balance*, NFER Nelson, 1983

Galloway, D. *Schools, Pupils and Special Educational Needs*, Croom Helm, 1985

Gulliford, R. *Teaching Children with Learning Difficulties*, NFER Nelson, 1985

Weber, K.J. *Yes they Can: A Practical Guide for the Adolescent Slow Learner*, Open University Press, 1974

Science for children with special educational needs

Avon Education Authority. *Science for Pupils with Special Educational Needs: Guidelines for Science in Avon Schools, Paper 1*, Avon Education Authority, 1985

Foster, D. (ed.) *Teaching Pupils of Low Scientific Attainment*, Resources for Learning Development Unit (RLDU), Bishop Road, Bishopston, Bristol, BS7 8LS, 1984

Jones, A.V. *Science for Handicapped Children*, Souvenir Press, 1983

Jones, A.V. (ed.) *Science Education for Children with Special Educational Needs*, Physical Science Department, Trent Polytechnic, 1986

Kincaid, D. *Science for Children with Learning Difficulties*, Macdonald, 1984

Stephenson, S.C. *The Teaching of Science and Maths to the Blind*, Royal National Institute for the Blind, 224 Great Portland Street, London W1, 1980

Travers, N. *The Teaching of Science to Pupils of Low Educational Attainment*, Northumberland Education Authority, 1984

SSCR workshop: *Changing Practice to Meet Needs*

This workshop uses video material from science lessons to focus on some of the difficulties which face teachers when teaching students with learning difficulties. Through the case study of one teacher concerned to improve his practice with regard to these students, participants are able to see how he went about change. This includes a look into other science laboratories to observe other teachers who have been involved in curriculum development. The workshop activites encourage participants to reflect on their own practice and develop their own strategies for change.

References

The SSCR publications referred to in the text under the series title **Better Science** are not listed here.

0.1 DES. *Special Educational Needs: Report of the Committee of Enquiry into the Education of Handicapped Children and Young People (The Warnock Report)*, HMSO, 1978

0.2 Brennan, W.K. *Curriculum for Special Needs*, Open University Press, 1985

1.1 DES. *A Survey of Science in Special Education*, HMSO, 1986

1.2 *Science at Work*, materials published by Longmans, London, 1984

1.3 *Open Science*, materials published for Schools Council by Hart-Davis Educational and Hutchinson, 1974

1.4 *LAMP*, materials published by the Association for Science Education, Hatfield, 1976

1.5 Telfer, I. *et al. Half our Children*, Resources for Learning Development Unit, Avon (in press)

1.6 HMI. *Aspects of Secondary Education in England: A Survey by HM Inspectors of Schools*, HMSO, 1979

1.7 DES. *Report of Her Majesty's Inspectors on the Effects of Local Authority Expenditure Cuts on Education Provision in England*, HMSO, 1986

2.1 Riggall, A. *et al. Primary Science: Secondary Science Links and their Implications*, Leicestershire Education Authority, 1986

2.2 Arnold, R. *et al. Me? Teach Science? Some suggestions for starting to teach science to children with special educational needs*, Hampshire Education Authority (in press)

2.3 Coward, A. *et al. Science Think Books*, Wiltshire Education Authority, 1986

4.1 Wilson, G.T. and *CHASSIS: Cheshire Achievement of Scientific Skills in School*, Cheshire County Council, 1986

4.2 Thompson, B. *et al. Science Education for a Multicultural Society*, Leicestershire Education Authority, 1986

4.3 Browne, N. *Science down to Earth*, 1986 (available from Teachers' Centre, University of Coleraine)

4.4 Bowker, M.K. *et al. Problem Solving for the Less Able*, Hereford and Worcester County Council, 1986

4.5 Brierly, D. *et al. Technology 10–14*, Leicestershire Education Authority, 1986

4.6 Linnell, H.D. and Gibson, D. (coordinators) *Problem Solving for the Less Able in the 14 to 16 Years Age Group*, 1986 (available from P. Cannon, Stockport Teachers' Centre)

4.7 Cooper, R., Davidson, I. and Ross, K. SSCR group report *Language in Science Project*, Gloucestershire Education Authority, 1986 (available from L. Scott, STACC, Archdeacon Street, Gloucester)

4.8 Mundy, P. *et al. Oral Assessment in Science*, Hampshire Education Authority (in press)

4.9 Nellist, J. and Nicholl, B. 'How is science teaching organised?' in *ASE Science Teachers' Handbook*, Chapter 5, Hutchinson/ASE, London, 1986

The Secondary Science Curriculum Review (SSCR) was set up in 1981 to stimulate, through working groups of practising teachers, the development of science studies which would help to provide an appropriate science education for *all* young people growing up in a scientific and technological society — whatever their abilities or career intentions. Its concern was not only with the science curriculum — its contents, purposes, teaching methods and resources — but also with the role of science in general education and within the whole school.

The **Better Science: Curriculum Guides** are based on the combined experience of the Review's Central Team and the working groups. Each Guide deals with a different but significant area of concern. Together they aim to assist teachers both in devising a broader and more balanced approach to science studies and in enhancing their professional development. The intention throughout is not necessarily to provide answers but rather to provoke and encourage teachers' thinking about the various topics addressed.

This Guide, **Better Science: For young people with special educational needs,**

- examines science teachers' long-felt concern about the science education of children with learning difficulties;
- sets this important agenda item within the context of special education;
- concentrates on ways to provide access to science education by identifying and responding to individual needs;
- is aimed both at teachers in mainstream schools and those who teach in special schools and units.

ISBN 0 435 54821 2

Also available:

Better Science: A Directory of Resources contains details of a broad range of materials produced by local working groups and the Review's Central Team. It includes descriptive and evaluative statements on each piece of material listed.

Better Science: Making it happen summarises, for a wide audience, the thinking of the Review and provides a guide to implementing balanced science for all pupils.

Heinemann Educational Books/Association for Science Education for the School Curriculum Development Committee

Better Science: Key proposals 1
Better Science: Choosing content 2
Better Science: Making it relevant to young people 3
Better Science: Approaches to teaching and learning 4
Better Science: How to plan and manage the curriculum 5
Better Science: For both girls and boys 6
Better Science: Working for a multicultural society 7
Better Science: **For young people with special educational needs** 8
Better Science: Health and science education 9
Better Science: Building primary–secondary links 10
Better Science: Assessing progress 11
Better Science: Learning how to teach it 12